NEW IMKANUR RUKYAH CRITERIA FOR THE ESTABLISHMENT OF ISLAMIC CALENDAR IN MALAYSIA

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ABSTRACT

An Islamic calendar is the calendar used for the purpose of Islamic practices and culture. In Malaysia, the present calendar used is called Takwim *Imkanur rukyah*. This calendar set the beginning of the month based on certain criteria of crescent (*hilal*) visibility. The existing MABIMS criteria are; *hilal* altitude of not less than 2^o from the horizon and arc-length of *hilal*-sun not less than 3^o at sunset, or age of *hilal* at least 8 hours at sunset. In accordance with the dynamic nature of astronomy, the study of *Imkanur rukyah* criteria are carried out from time to time. The new criteria in this study are; when hilal position at an altitude of not less 4^o and arc-length of moon-sun not less than 6.4^o. The study was conducted to identify any shift at the beginning of the months, as a result of using this new criteria. From the analysis, it is found that within the 20 years period, *Zulkaedah* shifted the least which is by 3 times, followed by Safar and *Rabiul Akhir* by 4 times, while *Muharram, Jamadil Awal, Jamadil akhir, Rejab, Syaaban* and *Ramadan* by 5 times, Syawal by 6 times, Rabiul Awal by 7 times and the highest would be *Zulhijjah* which is by 8 times. Overall, there are 62 shifts occur out of 240 months involved, which equivalent to 25.8% in total.

Key words: Imkanur rukyah, hilal visibility criteria, Islamic calendar, MABIMS.

1.0 INTRODUCTION

An Islamic calendar or widely known as *hijri* calendar is the calendar used for the purpose of Islamic practices and culture. It is strictly lunar calendar. The Holy Quran states that the Islamic months begin by sighting the new moon, as in *Sura Al-Baqarah*, verse 189, which means: "*They ask you, (Muhammad), about the new moons. Say, "They are measurements of time for the people and for Hajj. And it is not righteousness to enter houses from the back, but righteousness is (in) one who fears Allah. And enter houses from their doors. And fear Allah that you may succeed".*

Determine the first day of each month of *Hijri* calendar is very important because it determines the Muslim festival days. Essentially, Muslims need to know when on the first day for fasting during Ramadan and when to celebrate *Hari Raya*. Thus, some practices have been adopted to determine the condition for *hilal* to be visible. Generally, there are two methods either by observation or calculation. However, observing the new moon has its own errors and limitations. Sometime the observation places do not have clear skies. Thus, the calculation of *hilal* visibility prediction from astronomical software or almanac plays its role in making the calendar. Criteria *Imkanur rukyah* by MABIMS is said to be rather low and certain group doubtful about it. In addition, there are several criteria have been discussed and studied internationally. Since there is none prediction criteria that 100% accurate, it is therefore these criteria are being looked into

year by year to obtain greater accuracy (Xin, 2001). The new criteria of *Imkanur rukyah,* which will be involved in this study, are basically in accordance with international criteria and also based on analysis of long term *hilal* observation data in Indonesia (Djamaluddin, 2010).

1.1 Concept of Islamic Calendar System

Formation of Islamic calendar is based on the circulation of the moon around the earth. It caused the moon illuminated face to change from day to day, from tiny crescent shape until it becomes full, and then narrowed again to be crescent again Kassim (2006). These changes are called phases of the moon. It begins with the new moon phase (**Figure 1**). The *hilal* will started to be visible after the *ijtimak* occurred, which is when the moon comes between the earth and the sun in a straight line (**Figure 2**).

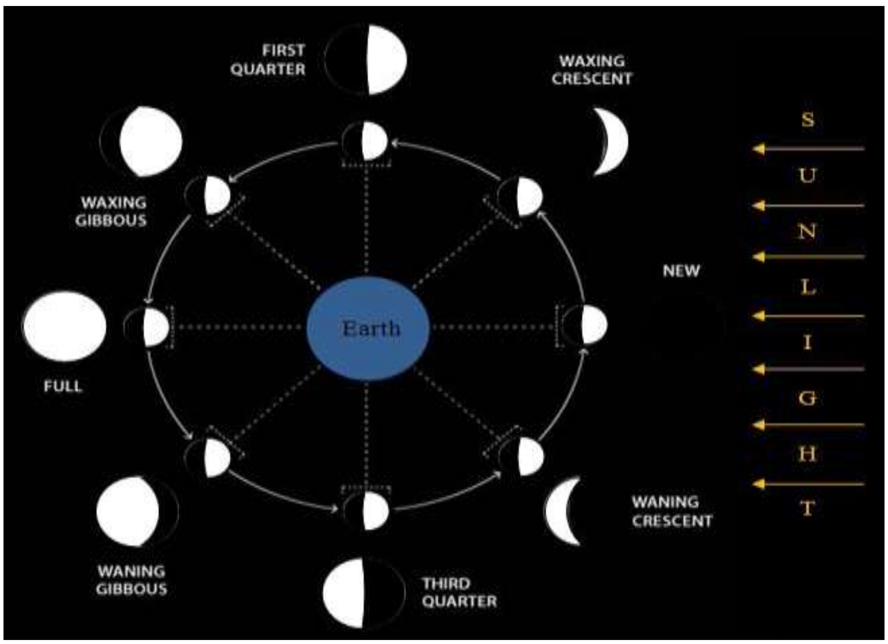

Figure 1 Position of Moon Phases

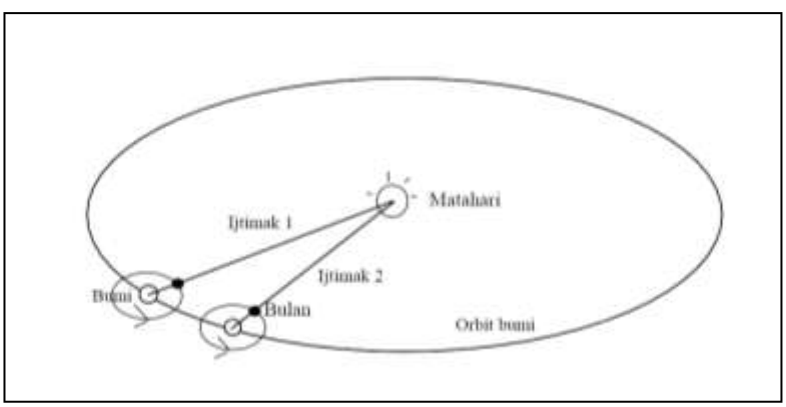

Figure 2 Position of sun, moon and earth during *Ijtimak*

New month begins when *hilal* can be seen at sunset. This is in line with the *hadith* that says:

"Fast as you see the hilal and break fast when you see the hilal. When the hilal was prevented by clouds from your view, then complete Syaaban with thirty (days). "

(Narrated by Imam Ahmad bin Hanbal)

1.2 Determination of New Months

As mentioned earlier, there are two methods for determine the beginning of new month which are by observation or calculation/prediction. Malaysia has adopted both of it which also called *rukyah* and *hisab* method. In brief, if the *hilal* can be sighted at the 29^{th} of the month, then the next day will be counted as the beginning of the next month. If it cannot be sighted due to bad weather or clouds cover the sky, then the data from *hisab* method will be used. If the calculation shows that *hilal* will not be visible, then the next day will be rounded to the 30^{th} of the month (Hamid, 1991). Methods of *rukyah* and *hisab* are interlinked with one another. Although the data of *hilal* visibility has been reviewed and predicted as can be seen, *rukyah* still have to be conducted to confirm that *hilal* will be visible at sunset. Some views from *ulamak* of *kitab Muktabar*, which means:

"And when the arithmetic shows the hilal is above the horizon, usually it can be seen if there is no barrier; such as cloudy, this indicates that fast is a must, because there is a reasonable sharie."

(*Kitab Syarqawi*, Al-Qusyairi's view)

The establishment of calendar shall be based on two important aspects namely scientific; the study of astronomy and the like, as well as aspects of *sharia*; which are the clear evidences from the Holy Quran and the *Hadith* of the Prophet Muhammad.

1.3 Criteria of *Imkanur Rukyah*

On June 1, 1992, located in Labuan, MABIMS (Ministers of Brunei, Indonesia, Malaysia and Singapore) have agreed to use criteria of *Imkanur Rukyah* as follows:

i. When the sun sets, *hilal* altitude above the horizon of not less than 2^o and the arc-length of *hilal*-sun of not less than 3^o

Or

ii. *Hilal* age is not less than 8 hours at sunset

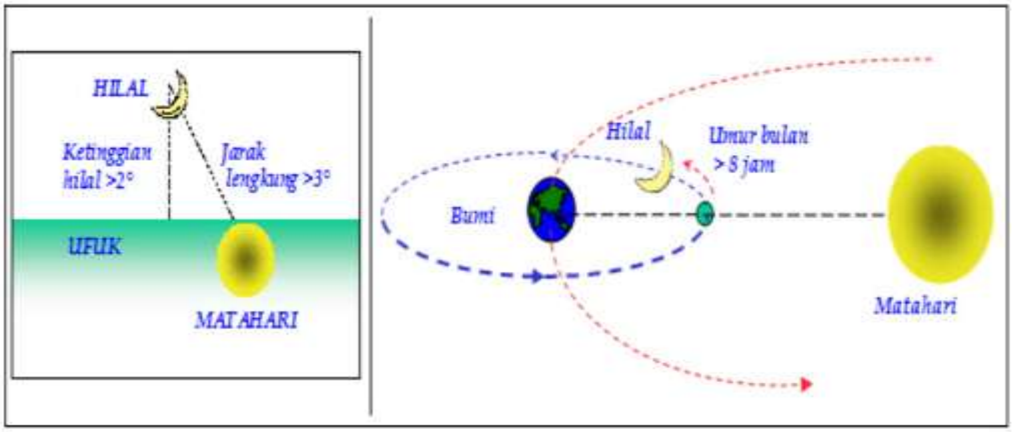

Figure 3 *Imkanur Rukyah* criteria of MABIMS

On the other side, the new Imkanur rukyah criteria are as follow:

i. Arc-length of *hilal*-sun not less than 6.4 ^{o} at sunset
ii. Differential in altitude of *hilal* and sun of not less than 4 ^{o} at sunset

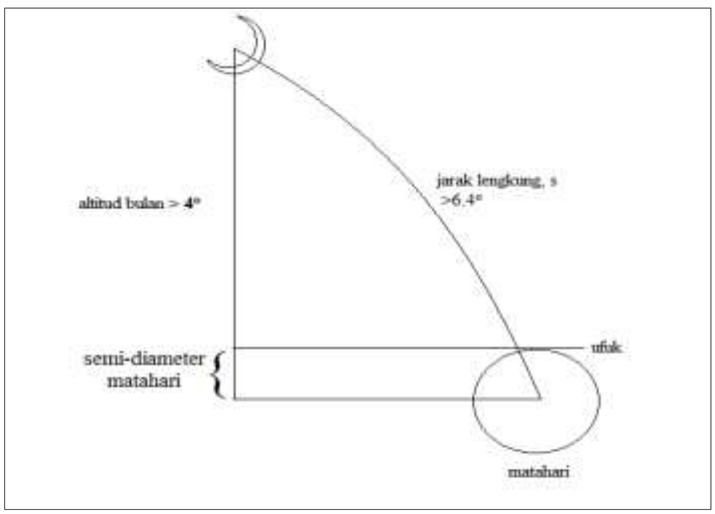

Figure 4 New Imkanur rukyah criteria

Basically, the criteria are based on several international criteria and long term observation data of Indonesia (Djamaluddin, 2010). The arc-length of *moon*-sun not less than 6.4 ^{o} is based on Danjon limit obtained by Odeh (2006). This limit is actually renewing Danjon limit by Schaefer (1991) of not less than 7^{o}, which is due to the limitations of human visual sensitivity. Limit by Odeh is set based on 737observation data, which nearly half of the data, were occupied from the Islamic Crescent Observation Project (ICOP). ICOP was formed in 1998 as a global Islamic project. It main purpose is as a means of gathering information about the results of *hilal* observations from different Islamic countries and regions around the world (http://www.icoproject.org). Therefore, every month, ICOP members who represent their places will submit the observations results, which then will be published on the website. From that, Odeh used about seven years of ICOP data to perform his analysis till he set the Danjon limit as 6.4 $^{o.}$

Whereas, the criteria that based on altitude-difference of moon-sun of not less than 4^o is according to Ilyas (1988) from his analysis on international criteria and also based on studies by Caldwey and Laney (2001). In fact, Ilyas gave criteria of altitude *hilal* as 4^o for a large azimuth separation of moon-sun, and 10.4^o altitude for different azimuth 0° (**Figure 5**). Alternatively, Caldwey and Laney distinguish the naked eye observation and observation with the aid of a sighting instrument, with minimum 4 ^{o} for large azimuth difference (**Figure 6**). In general, the criteria for minimum altitude can be summed up as 4 $^{o.}$

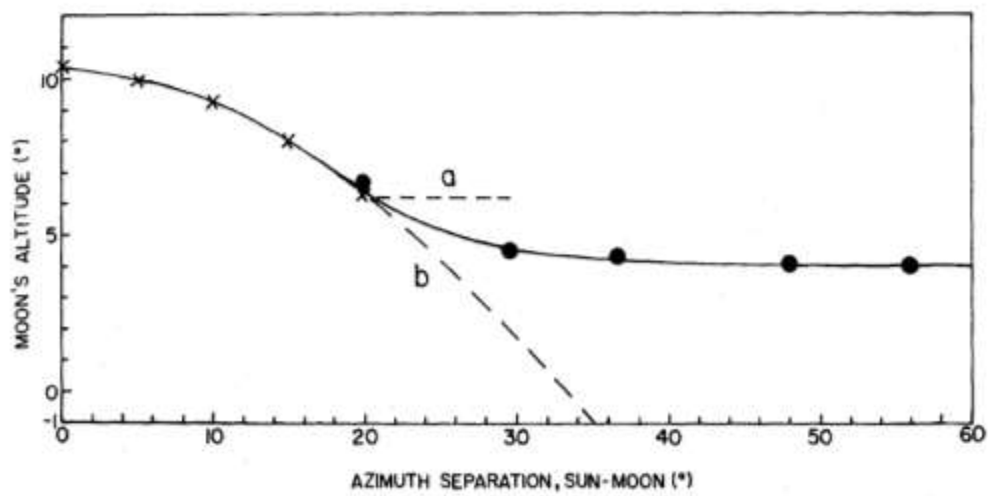

Figure 5: Advanced extrapolation of *hilal* altitude criteria, based on azimuth separation by Ilyas

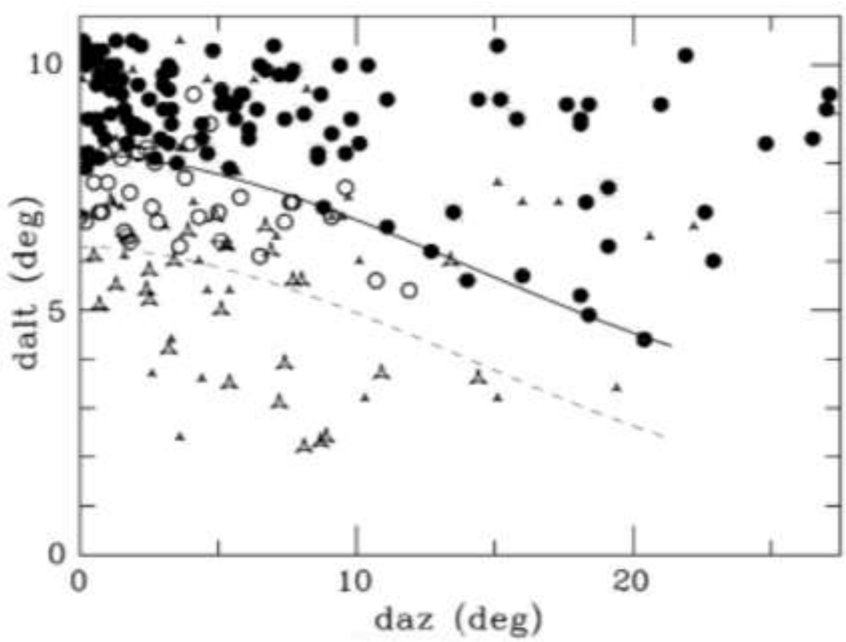

Figure 6: *Hilal* altitude criteria by distinguishing the naked eye observation (black circles) and observed with optical aids (white circle)

According to Djamaluddin (2010), these new criteria had been proposed for the determination of sole criteria of Indonesia. Geographically, Malaysia and Indonesia are located close together. It is therefore this new criteria has be reviewed in Malaysia. Based on study by Farhan (2010), it is proved that the existing *Imkanur Rukyah* criteria (MABIMS) are justifiable with the *hilal* visibility. However, he found that there are weaknesses in that criteria where it is quite low compared to the position of *hilal* that can be sighted in Malaysia (**Figure 7**).

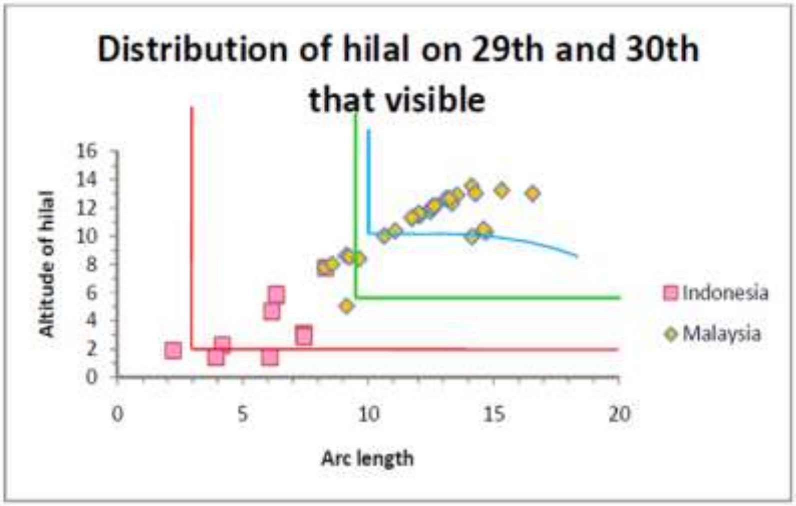

Figure 7: Distribution of *hilal* visibility based on *hilal* altitude and arc length *hilal*-sun

(Source: Farhan, 2010)

Based on **Figure 7**, the new criteria can be assumed as acceptable to be adopted in Malaysia because most of *hilal* that can be sighted is still within the new limit. Hence, this study will evaluate the differences of using the new criteria in the establishment of Islamic calendar system in Malaysia.

1.4 Multiyear Interactive Computer Almanac (MICA) Software

MICA is a software system created especially for astronomers, surveyors, meteorologists, navigators and others who regularly need accurate information on the positions and motions of celestial objects. It provides high-precision astronomical data for a variety of astronomical objects.

Many quantities in The Astronomical Almanac are given with respect to the centre of the earth (geocentric). Astronomical quantities (like rise/set/twilight times) that depend on the observer's location are typically tabulated in the Astronomical Almanac at set intervals of latitude and/date. The user often must perform additional calculations in order to obtain data for a specific location and/or time and date. MICA, unlike The Astronomical Almanac, computes this information for any specific date and location automatically. Meaning that, no additional computations should be necessary (U.S Naval Observatory, 2005).

Thus, the information needed for generating the data for this study were only the coordinate of reference station and the date of 29^{th} of Islamic month with respect to *Masehi* calendar. Later on, MICA computes the required data for example the position of the sun, position of the moon, and also the time of sunset and moonset. The computed data were then use to establish the Islamic calendar.

2.0 METHOD

There are two main parts of the method involved for achieving the objectives which are data preparation and the establishment of calendar.

2.1 Data Preparation

Data of moon and sun position on 29^{th} day of each month are generated using Multiyear Interactive Computer Almanac (MICA) software. The data comprises of time of *ijtimak*, time of sunset and moonset, altitude of the moon, azimuth of the moon, azimuth of the sun and also arc-length of moon-sun. Then these data were used to determine whether the criteria is fulfilled or not. Basically, if one of the criteria either moon altitude or arc-length of moon-sun did not reach the minimum limit, the next day will be counted as 30^{th} of the month. Whereas, if both criteria achieve the limits, then the next day will be counted as the first day of next month. Data of *hilal* position was compiled using Microsoft Word as in **Table 1**. The data was prepared for both existing and new criteria for 20 years period. The chosen reference station was Tanjung Cincin, Langkawi, Kedah (latitude = 6 ^{o} 26 '10 "North, longitude = 99 $^{\circ}$ 38' 30") as the most westerly location in Malaysia.

There are several steps to extract the required data from MICA. The phases of the moon was generated initially, in order to determine the day and time of new moon. Then followed by other data mentioned earlier, which can be seen clearly through the flow diagram below.

PHASES OF THE MOON

Phase	Date	Time (UT1)	Julian Date
		h m	d
Last Quarter	2013 Jan 5	3:58	2456297.6651
New	2013 Jan 11	19:44	2456304.3219
First Quarter	2013 Jan 18	23:45	2456311.4896
Full	2013 Jan 27	4:38	2456319.6933
Last Quarter	2013 Feb 3	13:56	2456327.0807
New	2013 Feb 10	7:20	2456333.8056
First Quarter	2013 Feb 17	20:31	2456341.3546
Full	2013 Feb 25	20:26	2456349.3514
Last Quarter	2013 Mar 4	21:53	2456356.4116
New	2013 Mar 11	19:51	2456363.3271

Figure 8: Phases of the moon

Sun

Tg Cincin, Langkawi
Location: E 99°38'30.0", N 6°26'10.0", 10m
(Longitude referred to Greenwich meridian)

Time Zone: 8h 00m east of Greenwich

Date (Zone)	Begin Astron. Twilight	Rise	Az.	Transit	Alt.	Set	Az.	End Astron. Twilight
	h m	h m	°	h m	°	h m	°	h m
2013 Jan 12 (Sat)	06:22	07:36	112	13:30	62S	19:23	248	20:37

Figure 9: Time of sunset

Moon

Tg Cincin, Langkawi
Location: E 99°38'30.0", N 6°26'10.0", 10m
(Longitude referred to Greenwich meridian)

Time Zone: 8h 00m east of Greenwich

Date (Zone)	Rise	Az.	Transit	Alt.	Set	Az.
	h m	°	h m	°	h m	°
2013 Jan 12 (Sat)	07:45	107	13:51	67S	19:57	255

Figure 10: Time of moonset

Moon

Apparent Topocentric Positions
Local Zenith and True North

Tg Cincin, Langkawi
Location: E 99°38'30.0", N 6°26'10.0", 10m
(Longitude referred to Greenwich meridian)

Date	Time (UT1)	Zenith Distance	Azimuth (E of N)	Distance to Object
	h m s	° ' "	° ' "	km
2013 Jan 12	11:23:00.0	83 1 09.6	253 32 42.5	362822.969

Figure 11: Azimuth and zenith distance of moon

Sun

Apparent Topocentric Positions
Local Zenith and True North

Tg Cincin, Langkawi
Location: E 99°38'30.0", N 6°26'10.0", 10m
(Longitude referred to Greenwich meridian)

Date	Time (UT1)	Zenith Distance	Azimuth (E of N)	Distance to Object
	h m s	° ' "	° ' "	AU
2013 Jan 12	11:23:00.0	90 47 15.9	248 22 44.8	0.983552743

Figure 12: Azimuth of sun

The flow diagram above is an example of data generating processes for 12th January 2013. All the data are then reassembled in **Table 1.** The first line in a row reflects the data for existing calendar while the second line is the data for new calendar. The star (*) sign means the data for new calendar were the same as for the existing calendar.

Based on the data, primary analysis was performed by assessing the altitude of *hilal* and arc-length of moon-sun to determine the beginning of next month. As mentioned before, if MABIMS criteria are achieved while new criteria are not, then for MABIMS calendar, the next day is set as 1st while for new calendar, the 1st day of next month will be delayed. As an example, for year 2013 (**Table 1**), 1st January 2013 was determine to be equal to 18 Safar 1434 for both criteria. Thus, 29 Safar would fall on 12th January. Therefore, the moon and sun position data were prepared for that day.

In MICA, the new moon phase reflects the time of *ijtimak*. **Figure 8** show that *ijtimak* will occur on 11th January 2013 at 19:44 UT time. Malaysia is located in the 8 hour time zone ahead from Greenwich Mean Time (GMT) and Coordinated Universal Time (UT/UTC). Therefore, to obtain time of *ijtimak* in Malaysian Standard Time (MST), the time in **Figure 8** has been added with 8 hours. Then the date and time of *ijtimak* befall on 12th January at 3:44.

The time of sun set was calculated to be occurred at 19:23 while the time of moon set is at 19:57 (from **Figure 9** and **Figure 10**). Both times are already shown in MST. Time of moon set is a bit late from time of sun set. This situation shows that the moon will be above horizon for a while after the sunset occurs. It means that there is a possibility that *hilal* can be sighted on that day. Hence, the geometrical factor of sun and moon position; which are the altitude and arc-length, are taken into account to determine either *hilal* can be visible by the observer or not.

Zenith distance and azimuth of moon were calculated as in **Figure 11** to be 83^o 1' 10" and 253^o 32'43" respectively. Thus, simple calculation was done to occupy the altitude value as 6^o 58'50" by using the following formula,

$$\text{Altitude of the moon, } \alpha_B = 90^o - \text{zenith distance}$$

whereas, azimuth of sun set was also calculated to be 248^o 22'45". Theoretically, the calculation of moon altitude is based on:

$$\sin h = (\sin \varphi . \sin \delta) + (\cos \varphi . \cos \delta . \cos t)$$

where,

h = altitude from the centre of the moon
φ = latitude of reference station
δ = declination of moon
t = hour angle of moon

while calculations of moon and sun azimuth is based on:

$$\tan z = \sin t / (\cos \varphi \tan \delta - \sin \varphi \cos \delta)$$

where,

z = Azimuth of moon or sun
φ = latitude of the reference station
δ = declination (moon or sun)
t = hour angle (moon or sun)

MICA cannot provide the arc-length of moon-sun directly. Therefore, Microsoft Excel has been used to calculate this value. From the data that have been acquired above, the calculation of arc-length of *moon*-sun was done by applying the following formula:

$$\cos s = \cos (h + SD) \text{ cost of } \Delta A$$

where s is the arc-length of moon-sun, h is the altitude of the moon at sunset, SD is the semi-diameter of sun and ΔA is the difference of azimuth from the centre of the moon to the centre of the sun. Hence, the arc-length of moon-sun on 12th January was obtained as $8^{o}53'31''$. Based on these data, it is seen that altitude value and arc-length value achieved the limit of both existing criteria and new criteria. It is therefore, for both calendar (see **Table 2** and **Table 3**), the beginning of Rabiul Awal 1434 will fall on the same date which is on 13th February 2013. The same analysis was implemented for the following months until 31st December to attain a complete data for one year calendar.

An example of the months that shifted at its beginning can be seen on 29 *Jamadil Akhir* 1434 (10th May 2013), the *ijtimak* occur on that day at 8:28, while the sun will set at 19:30 and the moon will set at 19:48. From MICA, it is predicted that altitude of moon during sunset is 3° 19' 17" and from a simple calculation, the arc-length of moon-sun will be 3° 35' 17". This condition will only satisfy MABIMS criteria. It is therefore in MABIMS calendar, May 11, 2013 will become 1 Rejab 1434 and as for new calendar, it will delay to May 12, 2013. This difference was highlighted and can be seen clearly as in **Table 3** in the next part.

Data preparation for analysis of these criteria was focused more on the moon and sun geometry information, which are the altitude of the moon and the arc-length between these two celestial bodies at the time of sunset. Moon's age is not so focused. This is because the age of the moon is considered as common or additional criteria. Sometimes, even if it has enough 8 hours, the position of *hilal* at the time of sunset is too close to the horizon (below the specified altitude limit) and cause difficulties to observe it. Schaefer (1996) have shown some errors if using the criteria of moon's age, while Odeh (2006) emphasize that the criteria of moon's age has nothing to do with the visibility of *hilal* by observer. Therefore, the criteria of moon's age is only an additional or alternative criteria in our country, together with two important criteria in terms of geometry as described before.

2.2 Establishment of Calendar

The calendar has been established based on the compilation of *hilal* position data as in **Table 1**. The date of the 1st day for each month was determined with respect to *Masehi* date. The calendar was then established for each year within the 20 years period by using Microsoft Excel. The calendar format is basically referred to the existing calendar published by JAKIM. The 1st day of the month that is shifted was highlighted in the calendar of new criteria so that easily identified and compared. Examples of the calendar for both existing and new criteria are shown in **Table 2** and **Table 3.**

Table 2: *Hijri* calendar for the year 2013 (1434/1435H) based on the existing criteria

TARIKH	JAN		FEB		MAC		APR		MEI		JUN		JUL		OGS		SEP		OKT		NOV		DIS	
	SAF		RAW		RAK		JAW		JAK		REJ		SYB		RAM		SYW		ZKH		ZHJ		MUH	
	1434		1434		1434		1434		1434		1434		1434		1434		1434		1434		1434		1435	
1	18	T	20	J	18	J	20	I	20	R	22	S	22	I	23	K	25	A	25	T	27	J	27	A
2	19	R	21	S	19	S	21	T	21	K	23	A	23	T	24	J	26	I	26	R	28	S	28	I
3	20	K	22	A	20	A	22	R	22	J	24	I	24	R	25	S	27	T	27	K	29	A	29	T
4	21	J	23	I	21	I	23	K	23	S	25	T	25	K	26	A	28	R	28	J	30	I	1 SAF	R
5	22	S	24	T	22	T	24	J	24	A	26	R	26	J	27	I	29	K	29	S	1 MUH	T	2	K
6	23	A	25	R	23	R	25	S	25	I	27	K	27	S	28	T	30	J	1 ZHJ	A	2	R	3	J
7	24	I	26	K	24	K	26	A	26	T	28	J	28	A	29	R	1 ZKH	S	2	I	3	K	4	S
8	25	T	27	J	25	J	27	I	27	R	29	S	29	I	1 SYW	K	2	A	3	T	4	J	5	A
9	26	R	28	S	26	S	28	T	28	K	30	A	30	T	2	J	3	I	4	R	5	S	6	I
10	27	K	29	A	27	A	29	R	29	J	1 SYB	I	1 RAM	R	3	S	4	T	5	K	6	A	7	T
11	28	J	30	I	28	I	30	K	1 REJ	S	2	T	2	K	4	A	5	R	6	J	7	I	8	R
12	29	S	1RAK	T	29	T	1 JAK	J	2	A	3	R	3	J	5	I	6	K	7	S	8	T	9	K
13	1 RAW	A	2	R	1 JAW	R	2	S	3	I	4	K	4	S	6	T	7	J	8	A	9	R	10	J
14	2	I	3	K	2	K	3	A	4	T	5	J	5	A	7	R	8	S	9	I	10	K	11	S
15	3	T	4	J	3	J	4	I	5	R	6	S	6	I	8	K	9	A	10	T	11	J	12	A
16	4	R	5	S	4	S	5	T	6	K	7	A	7	T	9	J	10	I	11	R	12	S	13	I
17	5	K	6	A	5	A	6	R	7	J	8	I	8	R	10	S	11	T	12	K	13	A	14	T
18	6	J	7	I	6	I	7	K	8	S	9	T	9	K	11	A	12	R	13	J	14	I	15	R
19	7	S	8	T	7	T	8	J	9	A	10	R	10	J	12	I	13	K	14	S	15	T	16	K
20	8	A	9	R	8	R	9	S	10	I	11	K	11	S	13	T	14	J	15	A	16	R	17	J
21	9	I	10	K	9	K	10	A	11	T	12	J	12	A	14	R	15	S	16	I	17	K	18	S
22	10	T	11	J	10	J	11	I	12	R	13	S	13	I	15	K	16	A	17	T	18	J	19	A
23	11	R	12	S	11	S	12	T	13	K	14	A	14	T	16	J	17	I	18	R	19	S	20	I
24	12	K	13	A	12	A	13	R	14	J	15	I	15	R	17	S	18	T	19	K	20	A	21	T
25	13	J	14	I	13	I	14	K	15	S	16	T	16	K	18	A	19	R	20	J	21	I	22	R
26	14	S	15	T	14	T	15	J	16	A	17	R	17	J	19	I	20	K	21	S	22	T	23	K
27	15	A	16	R	15	R	16	S	17	I	18	K	18	S	20	T	21	J	22	A	23	R	24	J
28	16	I	17	K	16	K	17	A	18	T	19	J	19	A	21	R	22	S	23	I	24	K	25	S
29	17	T			17	J	18	I	19	R	20	S	20	I	22	K	23	A	24	T	25	J	26	A
30	18	R			18	S	19	T	20	K	21	A	21	T	23	J	24	I	25	R	26	S	27	I
31	19	K			19	A			21	J			22	R	24	S			26	K			28	T
	RAW		RAK		JAW		JAK		REJ		SYB		RAM		SYW		ZKH		ZHJ		MUH		SAF	
	1434		1434		1434		1434		1434		1434		1434		1434		1434		1434		1435		1435	

A = Sunday, I = Monday, T = Tuesday, R = Wednesday, K = Thursday, J = Friday, S = Saturday

Table 3: *Hijri* calendar for the year 2013 (1434/1435H) based on the new criteria

TARIKH	JAN		FEB		MAC		APR		MEI		JUN		JUL		OGS		SEP		OKT		NOV		DIS	
	SAF		RAW		RAK		JAW		JAK		REJ		SYB		RAM		SYW		ZKH		ZHJ		MUH	
	1434		1434		1434		1434		1434		1434		1434		1434		1434		1434		1434		1435	
1	18	T	20	J	18	J	20	I	20	R	21	S	22	I	23	K	24	A	25	T	26	J	27	A
2	19	R	21	S	19	S	21	T	21	K	22	A	23	T	24	J	25	I	26	R	27	S	28	I
3	20	K	22	A	20	A	22	R	22	J	23	I	24	R	25	S	26	T	27	K	28	A	29	T
4	21	J	23	I	21	I	23	K	23	S	24	T	25	K	26	A	27	R	28	J	29	I	30	R
5	22	S	24	T	22	T	24	J	24	A	25	R	26	J	27	I	28	K	29	S	1 MUH	T	1 SAF	K
6	23	A	25	R	23	R	25	S	25	I	26	K	27	S	28	T	29	J	30	A	2	R	2	J
7	24	I	26	K	24	K	26	A	26	T	27	J	28	A	29	R	1 ZKH	S	1ZHJ	I	3	K	3	S
8	25	T	27	J	25	J	27	I	27	R	28	S	29	I	30	K	2	A	2	T	4	J	4	A
9	26	R	28	S	26	S	28	T	28	K	29	A	30	T	1 SYW	J	3	I	3	R	5	S	5	I
10	27	K	29	A	27	A	29	R	29	J	1 SYB	I	1 RAM	R	2	S	4	T	4	K	6	A	6	T
11	28	J	30	I	28	I	30	K	30	S	2	T	2	K	3	A	5	R	5	J	7	I	7	R
12	29	S	1 RAK	T	29	T	1 JAK	J	1 REJ	A	3	R	3	J	4	I	6	K	6	S	8	T	8	K
13	1 RAW	A	2	R	1 JAW	R	2	S	2	I	4	K	4	S	5	T	7	J	7	A	9	R	9	J
14	2	I	3	K	2	K	3	A	3	T	5	J	5	A	6	R	8	S	8	I	10	K	10	S
15	3	T	4	J	3	J	4	I	4	R	6	S	6	I	7	K	9	A	9	T	11	J	11	A
16	4	R	5	S	4	S	5	T	5	K	7	A	7	T	8	J	10	I	10	R	12	S	12	I
17	5	K	6	A	5	A	6	R	6	J	8	I	8	R	9	S	11	T	11	K	13	A	13	T
18	6	J	7	I	6	I	7	K	7	S	9	T	9	K	10	A	12	R	12	J	14	I	14	R
19	7	S	8	T	7	T	8	J	8	A	10	R	10	J	11	I	13	K	13	S	15	T	15	K
20	8	A	9	R	8	R	9	S	9	I	11	K	11	S	12	T	14	J	14	A	16	R	16	J
21	9	I	10	K	9	K	10	A	10	T	12	J	12	A	13	R	15	S	15	I	17	K	17	S
22	10	T	11	J	10	J	11	I	11	R	13	S	13	I	14	K	16	A	16	T	18	J	18	A
23	11	R	12	S	11	S	12	T	12	K	14	A	14	T	15	J	17	I	17	R	19	S	19	I
24	12	K	13	A	12	A	13	R	13	J	15	I	15	R	16	S	18	T	18	K	20	A	20	T
25	13	J	14	I	13	I	14	K	14	S	16	T	16	K	17	A	19	R	19	J	21	I	21	R
26	14	S	15	T	14	T	15	J	15	A	17	R	17	J	18	I	20	K	20	S	22	T	22	K
27	15	A	16	R	15	R	16	S	16	I	18	K	18	S	19	T	21	J	21	A	23	R	23	J
28	16	I	17	K	16	K	17	A	17	T	19	J	19	A	20	R	22	S	22	I	24	K	24	S
29	17	T			17	J	18	I	18	R	20	S	20	I	21	K	23	A	23	T	25	J	25	A
30	18	R			18	S	19	T	19	K	21	A	21	T	22	J	24	I	24	R	26	S	26	I
31	19	K			19	A			20	J			22	R	23	S			25	K			27	T
	RAW		RAK		JAW		JAK		REJ		SYB		RAM		SYW		ZKH		ZHJ		MUH		SAF	
	1434		1434		1434		1434		1434		1434		1434		1434		1434		1434		1435		1435	

A = Sunday, I = Monday, T = Tuesday, R = Wednesday, K = Thursday, J = Friday, S = Saturday

The tables above are the examples of Islamic calendar of Malaysia for year 2013 (1434/1435) for both existing criteria and new criteria correspondingly. The 1st day of each month was colored with light blue, while the dark yellow indicates the shifted dates. From the calendars, it is seen that in year 2013, there are 4 shifts occur which are in *Rejab* 1434, *Syawal* 1434, *Zulhijjah* 1434 and *Safar* 1435. For the existing calendar, 1 Rejab will fall at 11th May but for new calendar, it will fall at 12th May. The same situation occurs for the other three months where for existing calendar, 1 *Syawal* = 8th August, 1 *Zulhijjah* = 6th October, 1 *Safar* = 4th December, and as for new calendar, 1 *Syawal* = 9th August, 1 *Zulhijjah* = 7th October and 1 *Safar* = 5th December. From this situation, it is noticed that the date for new calendar will be delayed by one day; it is rarely found the date of new calendar be earlier, compared to the existing calendar. Meanwhile the other 8 months are having the same date. All the months for each year that experience the shifts were then assemble in **Table 4** in **part 3.0**.

3.0 ANALYSIS AND RESULTS

Table 4 The months that have shifted on its 1st day (1433-1452H)

Year (Hijriah/Masehi)	Muh	Saf	Raw	Rak	Jaw	Jak	Rej	Syb	Ram	Syw	Zkh	Zhj	Total
1433/2011-2012				x			x						2
1434/2012-2013							x			x		x	3
1435/2013-2014		x								x			2
1436/2014-2015	x		x		x			x					4
1437/2015-2016	x			x		x			x				4
1438/2016-2017	x				x		x			x			4
1439/2017-2018					x	x		x			x		4
1440/2018-2019		x			x	x						x	4
1441/2019-2020			x			x			x				3
1442/2020-2021	x								x	x		x	4
1443/2021-2022		x					x			x		x	4
1444/2022-2023			x		x							x	3
1445/2023-2024			x			x					x		3
1446/2024-2025			x	x					x			x	4
1447/2025-2026				x						x			2
1448/2026-2027	x						x	x			x		4
1449/2027-2028		x						x					2
1450/2028-2029			x					x				x	3
1451/2029-2030									x			x	2
1452/2030-2031			x										1
Total	5	4	7	4	5	5	5	5	5	6	3	8	62

Table 4 shows the months that have shifted on its 1st day within the 20 years period. The years involve was from 1433H until 1452H (end of 2011 until 2031). From the table, it is seen that most of the years are having about 2 to 4 times shifted occur. In detail, there are 9 years that having 4 differences (1436H until 1440H, 1442H, 1443H, 1446H and 1448H), 5 years having 3 differences which are 1434H, 1441H, 1444H, 1445H and 1450H, and 5 years having 2 differences which are 1433H, 1435H, 1447H, 1449H and 1451H. However, in year 1452, only once the shift occurs which is at the beginning of *Rabiul Awal*.

While from months view, average shifted that occur are 5 times. This can be seen in Muharram and *Jamadil Awal* until *Ramadan*. Accordingly it means that 6 months out of 12 are having 5 times differences. The months that experience shifted the most is *Zulhijjah* by 8 times which are in years 1434H, 1440H, 1442-1444H, 1446H, 1450H and 1451H. Followed by *Rabiul Awal* by 7 times which are in years 1436H, 1441H, 1444-1446H, 1450H and 1452H, and *Syawal* by 6 times in years 1434H, 1435H, 1438h, 1442H, 1443H and 1447H. The month that having the least shift is *Zulkaedah* by 3 times only. It shifted in years 1439H, 1445 and 1448H. Whereas the remains two months which are *Safar* and *Rabiul akhir* follows by having 4 times differences in years of 1435H, 1440H, 1443H, 1449H, and 1433H, 1437H, 1446H, 1447H respectively. The results were then presented in the form of graph as in **Figure 13**.

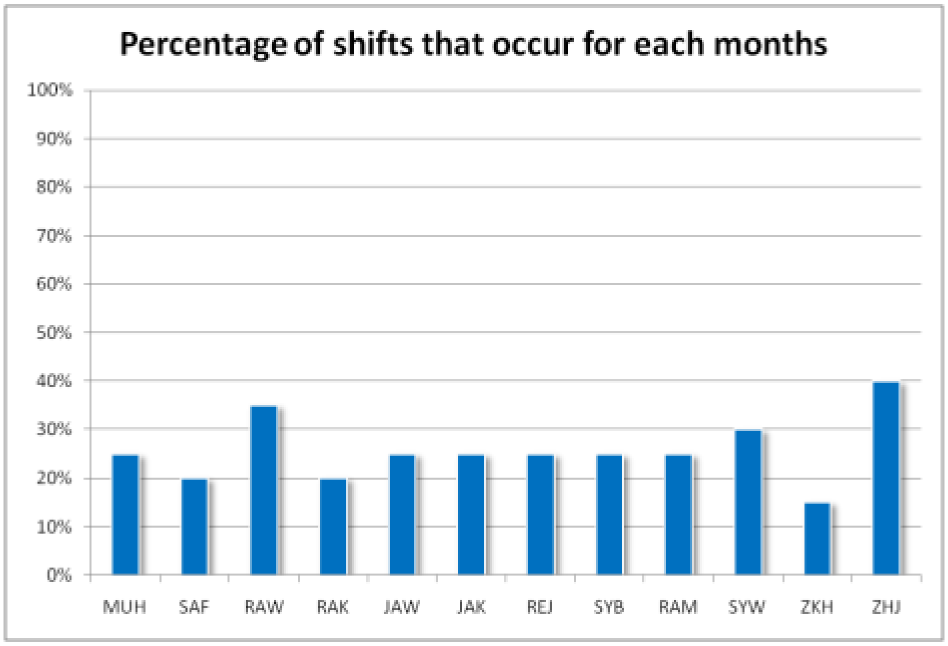

Figure 13: Percentage of the shifts that occur for each Islamic month in 20 years

By referring to **Table 4** and **Figure 13**, overall, there are 62 shifts occur within the 20 years period. In summary, *Zulhijjah* have shifted the most by 40%, followed by *Rabiul Awal* and *Syawal* with the percentage of 35% and 30% respectively. Other months mostly experience 25% displacement, followed by *Safar* and *Rabiul Akhir* with 20% and *Zulkaedah* by only 15%.

Three important months that has been highly concerned are Ramadan, Syawal and Zulhijjah. As mentioned earlier, these months imply the foremost muslim festival day and worship which are the beginning of fasting month (1 *Ramadan*), *Hari raya* (1 *Syawal*) and feast of *Aidil Adha* (10 Zulhijjah). If the numbers of shift that occur are critical, especially for these months, then both existing and new criteria should be considered further through more detailed scientific study in future. As strained before, *Zulhijjah* had the most critical shift. It is the result of moon and sun position on the 29th *Zulkaedah* for not being able to meet the new criteria limits, while *Syawal* is affected by 29th of *Ramadan*, and *Ramadan* is affected by 29th of *Syaaban* and so on. Figures below illustrate the altitude of *hilal* and arc-length of moon-sun that lead to the shift occurrences for Zulhijjah, Syawal and Ramadan, in accordance to the year involved.

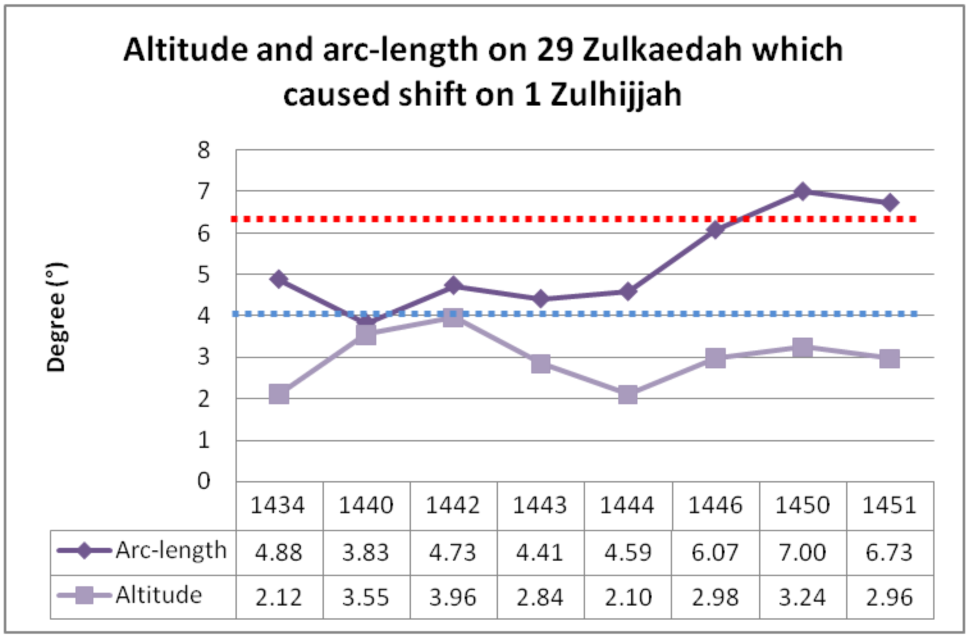

Figure 14: Zulhijjah

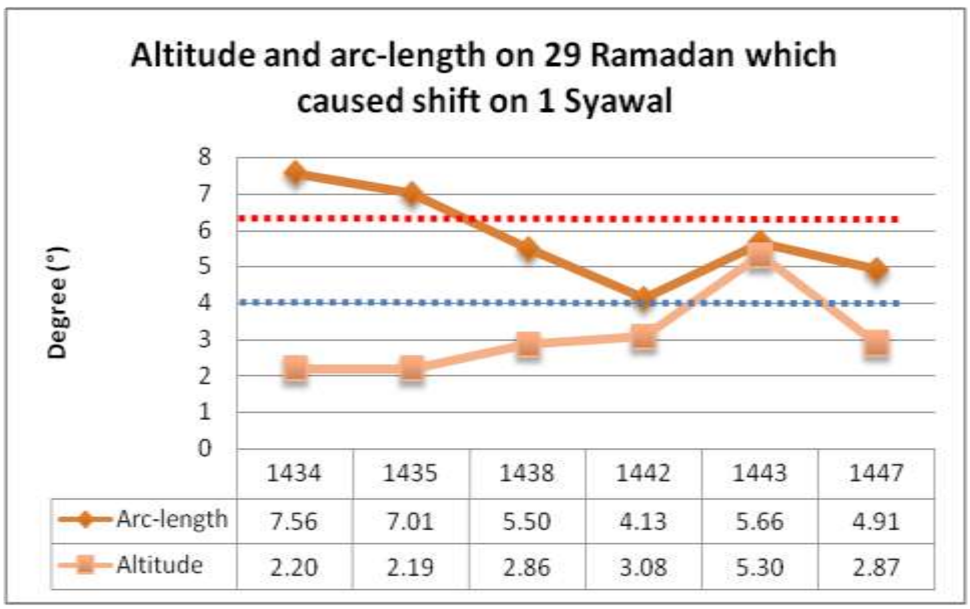

Figure 15: Syawal

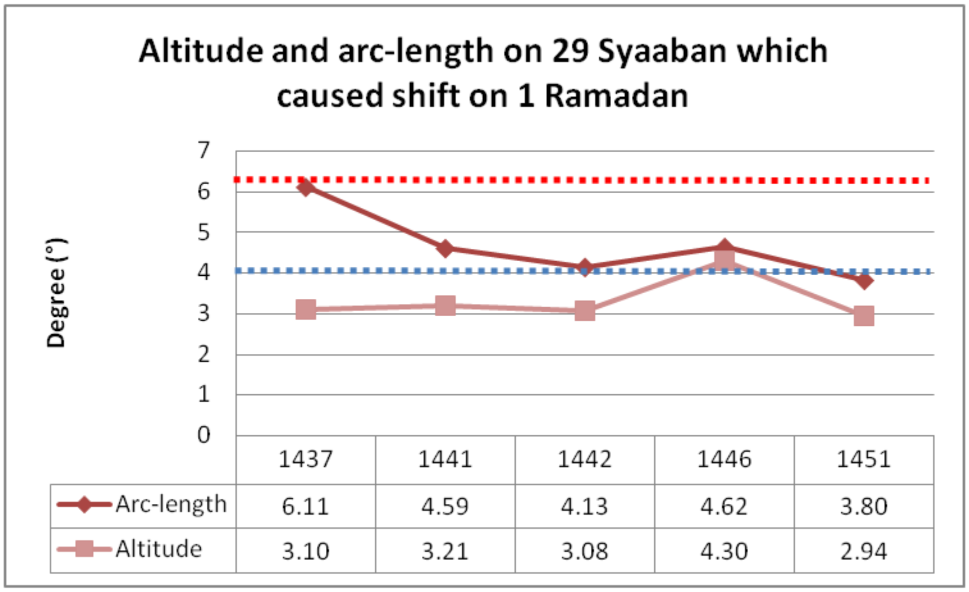

Figure 16: Ramadan

Figure 14 shows the values of altitude and arc-length on 29 *Zulkaedah* which affect the beginning of Ramadan according to the years. The blue line represents altitude limit (4^o) and the red line represents the limit of arc-length (6.4^o). The value for each graph point is shown in decimal degree format. From the graph, it is seen that, the first six years does not achieved both limit. Whereas, the two years after (1450H and 1451H), only the arc-length is reached by 7^o and 6.73^o, but altitude limit was unsuccessful which is by 3.24^o and 2.96^o respectively. Overall, the 8 shifts of *Zulhijjah* were led by the low value of altitude. None of the value was beyond 4^o. The highest value can be seen in year 1442H by 3.96^o, which is very near to the limit and only need about 0.04^o to pass. However, its arc-length is only 4.73^o; still rather low if to reach the new *hilal* visibility criteria. Thus, in average, *hilal* altitude is only between 2^o to 4^o, while arc-length is around 4^o, but sometimes goes up to 7^o.

As for *Syawal* (**Figure 15)**, the first two values of the arc-length were passes the limit, which is in year 1434H and 1435H. However, their altitude values were among the lowest by only 2.2^o and 2.19^o; still requires more than 1^o to reach the blue line. On the other hand, there is one value achieved the altitude condition by 5.3^o in year 1443H, but the arc-length value was only 5.66^o. In a whole, altitude value that contribute to date displacements is between 2-3^o and arc-length is between 4-6^o. In terms of new criteria, most of the shifts occurred is a result of low altitude values which cause the *hilal* for might not being possible to be seen. As for *Ramadan* (**Figure 16**), it is seen that only one of all the values reached the limit which is the altitude in year 1446H, but the arc-length is only around 4.62^o. None of the arc-length surpassed the limit. Most of it is below 5^o, while the altitude value is around 3^o.

From all of the graphs, it is seen that average of altitude value that result the shifts is between 2-3^{o}, even though the arc-length value sometimes can go up to 8^{o}. In fact, the altitude value of *hilal* during sunset represents aspects of the foreground contrast at the western sky, while the physical aspects of the *hilal* is indirectly represented by the arc-length of moon-sun; which is according to the value of azimuth differences (Djamaluddin, 2010). It is therefore, these two aspects of *hilal* geometry were very important to be considered in order to define the visibility of *hilal* by observer.

Theoretically, altitude of the moon is directly proportional to the arc-length of moon-sun. However, sometimes the situation could be reversed as seen in the graphs above. This is probably due to the difference in azimuth between the moon and the sun during sunset is too small which caused the *hilal* might not be visible. To sum up, most of the shifts occur due to invisible of *hilal*, were results of the low value of altitude, which then lead to low value of arc-length (in case of azimuth separation value is also low).

4.0 CONCLUSIONS

This study was conducted not to wrap up which criteria is correct and which is wrong. Only that there is a possibility to adopt other criteria instead of MABIMS criteria, because it is noticeably difficult to sight the moon based on many of previous study and *rukyah* experiences. It is therefore this preliminary study was implemented to find out the result of using the new criteria compared to the existing criteria, in the context of Islamic calendar establishment. From the analysis, it is found that there will be about 62 shift occurs out of 240 months involved, which equivalent to 25.8% in total. This situation is considered critical especially when the 3 important months (*Ramadan*, *Syawal* and *Zulhijjah*) are also shifted significantly. The result of this study should be taken into account by related parties responsible for the establishment of Islamic calendar in Malaysia. Even so, in order to strengthen the reliability of *Imkanur rukyah* criteria, many detailed study about both criteria is required from various perspectives in future. It supposed to include the scientific aspect, *sharia support*, and together with the compilation of more *rukyah* data of Malaysia.

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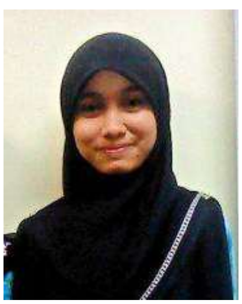

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